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*RESEARCH IN STATE UNIVERSITIES.**

THE word research, as used by scientific men, signifies study systematically carried on for the purpose of discovering that which is unknown. It is the seeking for new facts, new forces, new laws and new ideas without direct reference to their utility.

The word *re*-search has been chosen to express this high aim, rather than the same root without the prefix, because in most instances explorations have to be repeated, experiments performed again and again, and the advances made in any direction scrutinized from many points of view before the conclusions reached are deemed worthy of acceptance.

The field of research is not restricted to the laboratory or the library, but is as wide as the universe. It includes the study of man as well as his environment. It is essential alike to the growth of industries and the development of philosophies.

Research, then, is the painstaking endeavor to increase the world's store of knowledge in any department of human thought.

The Scope of Research.—One of the most important results of the modern development of industries is the recognition of the fact that discovery is the mainspring of progress. This conclusion, although self-evident, does not seem to have received the recognition it deserves. The creed which needs to be repeated over and over again in the hearing of every intelligent human

* Read before the Research Club of the University of Michigan, January 20, 1904.

being, in order that still greater achievements may be accomplished, is that all man has gained which makes him the superior of the beasts of the fields, has come as a reward for increasing his knowledge of the cosmos in which his lot is cast. The fact that progress depends on and is an outcome of human exertion, should stimulate and encourage all mankind to strive to reach a higher plane. The end in view is the attainment of all possible knowledge, and the application of that knowledge to the increase of man's happiness, the lessening of his burdens, and the decrease of his sufferings. The goal, on reaching which man can say: The bounds of the knowable have been attained, and all possible wisdom is mine! is not in sight. So vast and intricate are the laws and processes of nature and of mind, that the Ultima Thule of human endeavor will never be reached. But to approach and make nearer and nearer approximations to the magnificent ideal, like the alpine climber who seeks to scale some cloud-encompassed peak, we need no other guide than the assurance that all ascending paths lead toward it.

The uplifting of man by providing him with additional powers through research may, as just suggested, be illustrated by the tasks that mountaineers set for themselves. It is true that on a mountain's side all ascending paths lead toward its summit, but some are impassable, others beset with extreme difficulties, and only one perhaps is practicable. The discovery of that way is the mountaineer's hope. Many fruitless efforts must be made, but at last some one climber, more skilled, steadier of nerve, or stronger and more enduring than his companions, discovers the right way and others follow, guided and encouraged by his example and counsel. The foremost mountaineer is an explorer. Following in his foot-steps but improving the path he has made and discovering side excursions from it, others gain glorious alpine gardens, and traverse shimmering snow-fields never before pressed by human foot. In a similar manner, among those who strive to make advances into the realm of the unknown in other directions, some one investigator gifted beyond his fellows, inspired by a new idea, or discovering a new meaning in some well-known fact, like the successful mountaineer, leads the way. When such an advance is made, others are encouraged to follow and a new and wider view of nature is obtained. The all-important fact is that some one shall lead. Leaders in research have appeared from time to time and in increasing numbers as the importance of their services to mankind has become more and more appreciated and the demand for an increase of knowledge more general. Some of the pioneers in research have been greater than others, but all alike have assisted in the great work of extending the boundaries of the known. The recognition of the fundamental importance of research has been slow, and resulted from the observed increase with its advance in material gains, enhanced comforts, greater effectiveness of labor, better health and greater average length of life. As these and other similar results have been recognized, the demand for more knowledge, in order that still other forces might be utilized, has steadily increased, and never before in the world's history has this demand been greater than now.

In a large view of human advancement research work in pure philosophy, from which but little direct aid to industry is perhaps furnished, must be reckoned fully as important as the discoveries of the chemist, the physicist and others, which are widely utilized in enhancing man's material welfare. The discoveries in relation to the flow of electricity, or the studies which furnished a knowledge of the properties of steam, great as have been the re-

sults of their application, it is safe to say, have been no more beneficial to the human race than the researches which made known the mode of development of plants and animals. Electricity and steam have furnished power for the moving of ponderous matter, but *evolution* has given a mental force which has profoundly modified the philosophies of all civilized peoples, and as there is no doubt will be a means of discovering many new truths in the future. Advance in philosophy, ethics, etc., is no less dependent on research than is the growth of manufacture or commerce. But no separation of purely intellectual and purely industrial development is permissible, since, as there is abundant evidence for proving, progress in any department of human activity is followed by gains at other points along the frontier of the domain of the known.

The Bounds of the Knowable not yet Reached.—The incentive which leads men to devote their time and energy to research is an unquenchable thirst for knowledge. The unknown has fascinations which in all ages have awakened a response in the human breast. In the earlier stages of intellectual development, the mountains, the ocean, the caverns and other but little-known portions of the earth were peopled in imagination with gods, genii and fairies, both genial and malign. When reason supplants fancy and experiment undermines credulity, the voices from the unknown become still more alluring. They lead the astronomer to explore distant space where he finds no limit; the geologist to trace backward the history of the earth without discovering a beginning; the chemist and physicist to scrutinize the laws governing matter and force without untangling all of their complexities; the archeologist, the historian, the philosopher, the socialist and others to investigate man's estate and development, only to find the records failing before the beginning of thought is discernible; the biologist to describe and classify the manifold ways in which life is encased and study the functions of bone, muscle and nerve, only to learn that the longed-for insight as to what life really is recedes farther and farther as he advances. Along these and many other tributaries of the river of knowledge explanations have been carried without reaching their sources. On every hand and at no great distance, as shown by the explorations that have been made, the known merges with the unknown.

This same conclusion can be indicated in another way: The rate and character of a change that is taking place are frequently indicated by means of a curved line, which shows graphically, perhaps an increase, a culmination and a decline. By this means the rate at which human knowledge has increased might be plotted, but the curve would fail to indicate a maximum and give no suggestion of a decline. The nineteenth century has been termed the 'wonderful century,' and why? Because during that century scientific discovery, followed by invention, was carried on more systematically, more enthusiastically and by a larger number of skilled investigators than during any previous century. The tide of discovery and invention which made itself prominent during the century recently closed, and increased in force as the years of that century increased in number, is still advancing and, as it seems, with continuous acceleration. The intellectual tide-gauges of the world give no suggestion that the nineteenth-century wave of discovery has culminated. On the contrary, there is abundant evidence to show that the rate of intellectual development is still on the increase, and that yet more important conquests in the domain of the unknown than have illuminated the past will be made in the future. On our

graphic illustration of the world's progress, each year extends the curve upward.

The conclusion that the known is but a small fraction in comparison with the unknown is perhaps startling, yet in view of the recency of numerous discoveries and the increasing rate of the returns from more and more careful investigation, such seems to be the ratio of the sum total of man's knowledge to the possible discoveries of the future. To demonstrate this broad proposition, which if true is most stimulating to human endeavor, facts might be presented from any department of knowledge. We are saved the trouble of compilation in this connection, however, by the timely appearance of 'Year Book' No. 1 of the Carnegie Institution.

The officers of the Carnegie Institution, in seeking to learn how they might best apply the money placed at their disposal, obtained assistance from various advisory committees, consisting of from one to six scientific experts, and in several instances the committees themselves sought counsel from other leaders in research both in the United States and in foreign countries. The reports of the committees referred to cover 284 octavo pages, and deal in a broad way with the problems awaiting investigation in several but by no means all departments of learning. Some of the directions in which, in the opinion of the members of the committees, profitable research work can be done, are enumerated below, but it is not practical to review the entire category at this time, and, besides, in several important divisions the precise questions to be asked of nature are not formulated.

From the reports mentioned, we learn that botanists are desirous of broadening their science in at least two directions:

The first pertains to the relation of vegetation to environment in the United States. In this connection, studies are suggested as to the function and effect of the forest in humid regions in reference to the influence of trees on atmospheric moisture, precipitation and run-off, and the converse effect on the forest; and also similar studies respecting the plants of arid regions, for which purpose the establishment and maintenance of a desert botanical laboratory are advocated.

The second recommendation of the advisory committee on botany is in reference to the carrying on of extensive botanical explorations in Central America and the West Indies, for which outline plans are presented.

These are the only ways in which the committee seems to have thought it expedient to recommend the undertaking of research work by the Carnegie Institution, but even a novice in the science of plants can readily see that there are promising lines of work in many other directions.

The advisory committee on physics outlines a broad plan for establishing a well equipped physical laboratory to be devoted to research work in pure physics, with a corps of investigators, together with recommendations in reference to grants of money to be made to persons, societies, etc., engaged in physical research, but does not outline the problems to be attacked.

In reference to investigations pertaining to the earth, which are of mutual interest to both physicists and geologists, the advisory committee on geophysics outlines some of the more prominent problems which demand immediate attention.

Among the salient questions pertaining to the earth's gaseous envelope, or the *atmosphere*, are those of its origin, its mass, its mass-limitations, and its mass-distribution, the potential atmosphere absorbed in the ocean and in the body of the earth, its sources of depletion and enrichment, its function as a thermal blanket over the sea and land, the possible changes in its diathermacy and the relations of these to

great climatic changes, together with many related problems that enter profoundly into the interpretation of the earth's past, and seem to have immense importance to the future of the human race.

In reference to the waters of the earth, or the *hydrosphere,* the geophysicists desire an opportunity to investigate its origin, mass and mass distribution; the constancy or variations in the volume of the ocean and changes in its level in relation to the land; the part which the water-mass plays in the changes of the form of the earth; the origin, constancy, or variation of the ocean's salinity, and many other questions.

Concerning the rigid outer portion of the earth, or the *lithosphere,* the geophysicists would seek for information relating to the origin and maintenance of the continental platforms with their superposed mountains and plateaus, and of the oceanic basins, involving questions of rigidity, distribution of pressures, etc.; the agencies and conditions that make possible the prolonged periods of crustal quiescence recorded on the earth's surface by extensive plains produced by erosion; the nature and causes of the movements in the earth's crust which have produced crumplings and breaks or faults, and upraised mountains and plateaus, and are indicated also in a large way by continents and oceanic basins; the breaking, shearing and folding of the rocks leading on to the general problems of rock metamorphism, and a great group of intricate questions of a chemical and chemico-physical nature, including the flow of rocks, the destruction and genesis of minerals, the functions of included water and gases, the flow of material within the earth, the origin of ore deposits, the evolution and absorption of heat, and other phenomena that involve the effects of temperature, pressure, tension and resultant distortion on chemical changes and mineralogical aggregations.

Within the earth's outer crust lies what is termed the *centrosphere,* concerning which the advisory committee on geophysics states its desires as follows: The themes here are the kinds and distribution of the lithic and metallic materials in the deep interior; the states of the matter; the distribution of mass and of density and the consequent distribution of pressure; the origin and distribution of heat; the conductivities of the interior material under the pressure and heat to which it is subjected; the heat possibilities arising from supposed original gaseous condensation, or alternately from initial impact of aggregation; the heat of subsequent attractional condensation; the secular redistribution of heat within the earth, and its loss from the surface; the possible relations of redistribution of internal heat to volcanism and to deformation, and similar profound problems.

Long as the above category of as yet unsolved problems may seem, it by no means exhausts the lines of earth study suggested to the Carnegie Institution as awaiting elucidation. Laboratory experiments are outlined in reference to the effect of pressure on the melting point of rocks carried on at high temperatures and pressures, and through a wide range of material; the effect of temperature and pressure on thermal conductivity and on elasticity, with reference especially to the transmission through the earth of seismic tremors. Nor is this all; geophysical questions in reference to the relation of the earth to other bodies in the solar system, such as the deformation of the earth owing to the attraction of the sun and moon, thus furnishing a means for testing its rigidity, the history of oceanic tides and their influence on the earth's rotation. These and other questions lead to still greater problems such as the origin of the solar system and even the genesis of the stars.

It is not desirable to weary my readers with a more extended exposition of our ignorance concerning the earth on which we live, as outlined in the 'Year Book' from which citations have just been made, but I may perhaps be pardoned for mentioning that following the presentation of the larger problems referred to, comes a list of sixteen extensive groups of specific questions which demand for their solution the establishment and maintenance for a series of years of an extensive and well-equipped geophysical laboratory.

The immediate lesson illustrated by this catalogue of wants is: great as are the results of the geological studies already made, several chapters of the earth's history have yet to be written and nearly all of the chapters already in print need thorough revision.

In the 'Year Book' cited above, the desire for further knowledge on the part of geographers, meteorologists, chemists, paleontologists, zoologists, psychologists, anthropologists, bibliographers, engineers, physiologists, historians, mathematicians, etc., are outlined, and in each department the importance of pressing on with discovery is clearly and earnestly expressed.

It will perhaps be a surprise to many persons, that in the recommendations for research work made to the Carnegie Institution, astronomy occupies more space than is assigned to any other science. Seventy-three pages are devoted to outline plans of some of the ways in which the study of the heavens can be continued with the promise of valuable returns. If the oldest of the sciences has such hopes for the future, surely the outer boundary of the knowable is far distant.

There is another point of view by which the magnitude of the research work brought to the attention of the trustees of the Carnegie Institution may be estimated. About one half of the plans suggested by advisory committees are accompanied by estimates of cost. This category—including estimates in several instances for laboratories, observatories, biological stations, endowments, etc., and running expenses for a period of five years—calls for an expenditure of about \$16,000,000. The expense of all the investigations outlined for a period of five years may safely be placed at \$30,000,000, or three times the present capital of the Carnegie Institution. In this connection it is to be remembered that the institution does not propose to undertake any research already provided for by individuals, universities, societies, etc., but to supplement such work or cooperate in carrying it on. The plans to which attention has been directed are for investigations over and above those already initiated or likely to be made without the aid of the Carnegie Institution. And again, to some extent the work outlined is circumscribed by political limits and pertains to the United States.

This brief showing of the problem already in view will, I think, serve to sustain the statement made above, in reference to the vastness of the realm of the unknown which surrounds us on every side. To extend the limits of the known in all the directions in which scientific men are looking would certainly require the resources of many Carnegie institutions, and the time and energy of many generations of investigators.

Increasing Difficulty of Research.—In considering the aims of research and the means available for its encouragement, the increasing difficulties in the way of discovery as knowledge increases, should be clearly recognized. Not only this, but the tendency to feel that enough has been accomplished, or in other words, self-satisfaction, needs to be combated. Contentment is not the motto of the enquiring mind.

The close scrutiny, the hard and long-

continued work and the careful mental training required to continue making discoveries in an old field, are seemingly self-evident. In geographical explorations, the discoverer of a new land has a virgin field before him, concerning which the most trivial notes are of value. As exploration progresses, however, and more and more is known concerning a newly discovered land, the problems to be attacked become more and more difficult, require deeper thought, better equipment and broader preparation on the part of the would-be discoverer. But old fields yield rich returns, even to the geographer, as is shown by the conspicuous advances made in physiographic studies in the older portion of America during the past decade.

The increased difficulties of discovery as advances are made might be emphatically illustrated by any one of the older sciences. In astronomy, for example, as every one knows, greater precision has demanded better instruments. While the moon yielded abundant returns when observed with the small telescope of Galileo; to resolve the distant nebulæ, measure the motions of double stars and map the heavens, requires instruments of vastly greater power. To the work of observing and measuring, the astronomer has added the study of the physical condition and chemical composition of the matter composing the heavenly bodies, measurements of the heat emitted by the stars, etc., and in several divisions of his task assistance is had from photography. The increased accuracy demanded and the broadening of the scope of astronomy, particularly by the addition to it of spectroscopic work, has vastly augmented the expense of equipping and maintaining observatories, and also demanded greater and more varied preparation on the part of the men who explore the realm of distant space.

The increase in the size and excellence of the instruments required by astronomers is well known. The great observatories are in sight and open to the public. The beauty and costliness of the modern telescope, so complex with its many attachments that it might well be termed an astronomical engine, are apparent even to the casual observer. Both the interesting methods of observation and the startling results of astronomical study are described from time to time in newspapers and popular magazines. From these and other sources the growing needs of the astronomer as his work progresses are at least recognized, and to a great extent appreciated by the public, and broad-minded citizens have in many instances contributed money freely for the betterment of the tools with which he works.

The increase in size and in costliness of astronomical instruments and the broadening of the scope of astronomy, are but an illustration of what has taken place and is increasing from day to day, in every department of human thought. The chemist, physicist, biologist, meteorologist, geologist and explorers who are following other paths of learning are meeting with greater and greater difficulties and are demanding better facilities, in the way of laboratories, collections, libraries, etc., as their work advances. These demands, although in many instances less obvious to the public than those of the astronomer, are none the less pressing, and fully as important. In each of these departments of research and, as has been stated, in all branches of knowledge, as advances have been made, greater and greater skill and more and more thorough preparation are necessary on the part of the persons engaged in the work. To continue research and place in the hands of inventors, manufacturers, teachers and others still more efficient means for conducting their tasks, it is evident that communities, in order to reap still greater har-

vests, must supply better and more expensive equipment, and furnish still more efficient means for the training of the persons who do research work for them.

Recognition of the Importance of Research.—In America three important steps in the recognition of research are marked by enduring movements. These are: the *American Journal of Science,* the first volume of which appeared in 1818, and which has continued to be a record of investigation to the present day; the Smithsonian Institution, organized in 1846, which has for its motto, 'The increase and diffusion of knowledge among men'; and the Carnegie Institution, established in 1902, which, in the words of its generous founder, has for its aim 'the securing for the United States leadership in the domain of discovery and the utilization of new forces for the benefit of man.'

These three monuments mark not only the road of scientific but of industrial advance in America, since the latter follows in the footsteps of the former. The aims of the Carnegie Institution, in particular, should arrest the attention of every so-called practical man, since they recognize a principle that is invading and revolutionizing industry in all of its many branches, namely, the substitution of precise or scientific methods in place of 'rule of thumb,' and the seeking for legitimate gains by the application of original studies to the arts. In brief, it is becoming noised abroad that there is money in research.

In reference to the growing appreciation of the value of research, a few illustrations may not be amiss.

The recognition of the importance of research to the farmer is indicated by the work carried on at public expense by the Department of Agriculture at Washington. Although the so-called practical application of discoveries already available, is the avowed aim of this well-organized department by the government, yet many contributions to pure science have been made in its eighteen sub-departments or bureaus, and at the fifty-six experiment stations under its general supervision and located in nearly every state of the union. Research in pure science is a part of the work of the Weather Bureau, and of the Divisions of Chemistry, Entomology, Botany, Biology, Forestry, Soils, Public Roads, Animal Industry, etc., of the Department of Agriculture and supplemented by experiments in agriculture by nearly 700 men in the many agricultural experiment stations. The results of the investigations carried on in these many related fields of study, not only furnish direct aid to farmers throughout our broad land, but establish safeguards and quarantines about their pursuits, the money value of which can only be reckoned in millions of dollars annually.

The term 'chemical industries' applied to a large group of manufactures such as beet sugar, soda ash, Portland cement, etc., is a recognition of the fact that they are based on the research work of the chemical laboratory. But capitalists are no longer content to await returns from the investigator who may chance to devote his time and energies to the special field in which their money is invested, but establish laboratories of their own and employ research workers who can point out ways of improving processes and enlarging factories. So great is this demand that our universities are being called upon to supply trained men by the score, who are able to originate new methods as well as superintend work already in process. The recognition of the value of research in the factory is even more pronounced in Germany than on this side of the Atlantic, as is indicated by the fact that in that country a single chemical establishment employs continuously more than thirty doctors of science, the best the universities there can turn out, who devote

their entire time to original investigations. As is frankly conceded in England and other countries which are the industrial rivals of Germany, the marked enlargement of her manufacturing industries in the past decade is directly due, as may be said for the sake of emphasis, to her including brains among the raw materials used.

Research in pure physics, as is well known, has led to the mobilization and training of industrial armies, which have built railroads, telegraph and telephone lines, laid ocean cables, and erected wireless telegraphy stations, and in numerous other ways aided transportation and intercommunication, and enhanced the comforts and conveniences of every-day life.

The direct economic value of research work in geology is shown by the fact that nearly every civilized country, and many states and provinces within the limits of larger political organizations, carry on geological surveys. The principal object of such surveys is to furnish assistance in the discovery of materials of economic importance such as building stone, coal, petroleum, iron, etc., but while this is largely routine work and the application of knowledge already acquired, research work is necessary at almost every step. To discover mineral substances of commercial value the far-reaching laws governing the many ways in which such substances have been concentrated, recrystallized, etc., so as to be available for man's use, have to be investigated. In recognition of the fact that the geologist has but entered on the exploration of the treasures of the earth, every national and state geological survey favors research work in a high degree.

A moment's thought will suffice to show that the few instances just mentioned in which research is fostered, do not stand alone. In medicine, hygiene, engineering, economics and many other broad fields of activity the direct utility of seeking for more knowledge is apparent and widely recognized.

These brief statements in reference to the growing recognition of the value of scientific discoveries have been selected from a great number that might be presented, with the hope of making it clear that there is a *demand for research men.* Men are wanted who can not only conduct industries on long established methods, but who have the ability to originate new methods and discover and apply new principles, particularly in the way of doing cheaper and better that which is now being done and of utilizing that which is now being wasted.

Never before in the history of the world has the demand for intellectual leaders of industry been greater than at present. The direct material benefits to be derived from the application of the forces of nature to human ends are now more widely appreciated than ever before. With this appreciation go a demand for fresh explorations and a thirst for the results of research that are most stimulating and encouraging. To persons engaged in the business of education, these considerations must awaken the enquiry: How is this great and growing demand to be met?

Preparation for Research Work.—To a large extent, the men who have enlarged human knowledge have been men of genius —with a mental grasp stronger than their fellows. Thousands of people saw apples fall to the ground before Newton formulated the law of gravity, but lacked the ability to deduct the cause from the effect. So in all branches of learning some one man, more gifted than his contemporaries, has led the way into the unknown. Although genius is all important, even the man of genius must have training for his work, in order to make the best use of his exceptional endowments. Just what training is necessary is a difficult question to decide, especially for one who is not a

genius, and not a specialist in the line of work for which a student is to be prepared. To a large extent the specially qualified or exceptional man must decide for himself as to the mental equipment required for his individual work. The education of the exceptional man is a delicate task. Too much training in the methods others have followed may make him an imitator instead of a leader; too little training, and he may fail to acquire the mental tools necessary in his particular line of work. The best that can be done by universities desirous of encouraging their sons and daughters of exceptional ability to make the most of their mental gifts is, seemingly, to furnish them with opportunities to develop; to endeavor to train the body as well as the mind, to educate the hand as well as the head, to supply libraries, laboratories and gymnasiums, to all who may be inclined to cultivate and develop the higher strains of inheritance or the special variations latent in them. From the thousands who present themselves for this arduous work it is the duty of the university to select the few of exceptional ability and encourage them to devote their lives to the task of carrying on research in the direction in which they are especially qualified.

Once the exceptional man is discovered, the purely economic interests of the community, if no higher principle, demand that he be assisted in every practicable way in carrying on his great work. Here again the encouragement of genius is a delicate task. Discovery means close application and long continued and painstaking work. The discoverer, as previously suggested, may be likened to a mountain climber. He must put forth his best efforts, deny himself many of the pleasures of life, and toil on for the most part alone, so far as intellectual companionship is concerned. He is but a man, however, and lavish emoluments may lure him to walk in the customary paths leading through bowers of pleasure, to the neglect of the more rugged ways tending upward; too little aid may leave his task so difficult that a great part of his energy will be consumed in overcoming the difficulties of mere existence.

Both in the education of the thousands in order that the exceptional man may be found, and in the assistance the university may in its own interest extend to him as a research worker, the persons best qualified to act as trustees for the community are the men with sufficiently wide training, and at least an appreciation of the higher and more ennobling aims of discovery, who are interested in similar lines of work. Such men are to a great extent included in the faculties of the higher institutions of learning. Committees from several such faculties, it is to be presumed, would be best able to decide as to what extent the men with new ideas or of exceptional ability should receive financial assistance.

The Place of Research in the University. —In view of the several considerations touched upon in the preceding pages—namely, the catholic aims of research; the narrow bounds of the known; the fact that discovery is the all important initial step in applying the materials and forces of nature to man's use; the convincing evidence as to the general and widely spread awakening among the leaders of industry in reference to the economic importance of fresh discoveries; and the growing recognition of the fact that not only skill, but originality, pays—the question presents itself: What should be the attitude of communities and institutions of learning toward research? In this connection communities and institutions of learning may be considered together, since many schools, colleges and universities are supported by public taxation.

Public schools, state colleges and state universities, so far as is declared in the

laws creating them, are maintained for two principal reasons: first, because education tends in a conspicuous manner to promote integrity, refinement and all that speaks for good citizenship; and, second, to train students in various arts and professions in such a way that they will be enabled to serve efficiently the communities in which they live.

The recognized method of attaining these ends, to use a part of the motto of the Smithsonian Institution, is to *diffuse knowledge among men.* The frequently quoted ordinance passed by the Confederate Congress, in 1787, which records the planting of the seed from which the public school system of the United States has grown, reads:

"Religion, morality and knowledge being necessary to good government and the happiness of mankind, schools and the means of education shall forever be encouraged."

In this and, so far as I have been able to learn, in all subsequent legislation bearing on public education, there is no direct recognition of the fundamental principle expressed in the first clause of the Smithsonian's motto, namely, *the increase of knowledge,* and found in the first of the declared aims of the Carnegie Institution, which reads, *To promote original research, paying great attention thereto as one of the most important of all departments.*

The proclaimed purpose of education has been and to a paramount degree still is, the transmission of knowledge, without endeavoring to add to the assets of the bank on which drafts are made, or striving to train the student to discover new truths for himself. Teachers and professors in state schools, colleges and universities, so far as indicated by their contracts with the institutions they serve, are simply conveyors of knowledge previously gained. In a few universities in America, it is true, chairs of research have been endowed by individuals, and in two notable instances, namely, Johns Hopkins University and Clark University, institutions having research as their primary aim, have been founded by broad-minded citizens. In the main and almost entirely, however, such additions as have been made to the world's store of knowledge by teachers and professors are due to their individual zeal and industry during hours not occupied by routine work in the lecture room or the laboratory.

Admitting the argument sometimes advanced in justification of the neglect of research in state universities, namely, that the duties of such institutions are purely educational, and that they are not supported for the purpose of fostering research, the fact still remains that research is in itself a method of mental training of a high order and demands a place in our institutions of learning on account of its exceptional educational value. As stated by Sir Norman Lockyer in his recent presidential address before the British Association for the Advancement of Science, *research is now generally acknowledged to be the most powerful engine of education that we possess.* The inquiry into the secrets of the unknown necessitates not only rigid mental discipline on the part of its votaries, but is an incentive to exertion to a degree that no other phase of education presents. Not even the desire for technical training in order that pecuniary returns may be had awakens such an earnest desire to know, or stimulates the student to such untiring diligence as exploration in a chosen field. And, besides, in the present stage of the growth of knowledge in order to make fresh conquests, the investigator must become familiar with that which has already been accomplished along the path he is to follow, and at least have a working knowledge of the languages in which the results reached by his predecessors are re-

corded, as well as some understanding of the departments of learning closely related to his specialty. The lesson to be read between the lines in these statements is that research does not supplant other means of education, but supplements them and gives them vitality.

If the primary object of public education is the development of character and the making of good citizens, research must from this point of view also be given a higher place than the mere following in the footsteps of others, since its sole aim is the discovery of truth. The inquiry for truth implies painstaking accuracy, the searching criticism of one's own work and the seeking of criticism from others, the dissipation of false hypotheses, the cultivation of logical methods, fearless abandonment of long established prejudices, the acceptance of conclusions based on oft-repeated experiments no matter how disturbing to former opinions, the discounting of mere authority, and other ennobling attributes of the mind.

In the several particulars just mentioned and more besides, the superior educational value of research over the mere acquiring of knowledge already formulated and recorded in books seems self-evident.

From the considerations briefly and inadequately presented on the preceding pages, at least two important conclusions may be drawn: one is that research furnishes the only means man has of increasing his control over nature; and the other, that in thus enlarging his sway he cultivates his own powers and enchances his chances of still greater advancement. Or stated in other words: an increase in knowledge adds to man's economic resources and at the same time is an educational exercise which develops the higher faculties of the mind.

The attitude that the state should hold toward research is thus twofold; first, to secure for her citizens a knowledge of the materials and forces of nature which can be utilized for increasing their comforts and enhancing their happiness; and second, to supply her students with an efficient means for developing their mental powers and awakening in them a consuming desire for the truth.

This claim for the educational value of research, as already stated, does not imply the abandonment of present methods of education, but simply the adoption of another means of attaining the desired end. While observation should be encouraged at all stages of school and college life, owing to the broad preparation necessary for true research, it can not be expected that the student, unless a genius, will be able to make independent investigations before completing his college studies. The place for definite and final training in research must necessarily be in the university. Such training furnishes the keystone which completes the arch of public education and finishes the structure begun in the grade schools, and must of necessity be fashioned and prt in place in the university. It is not until this is done that the university ceases to be a high school of larger growth. In each college of a university a few students are usually graduated each year who desire to continue their studies and earn a master's and later a doctor's degree. These few, by a process akin to natural selection or the survival of the fittest, form a class by themselves and in general, owing to exceptional mental endowments, or more than ordinary diligence, are best qualified of all the sons and daughters of a university to become contributors to the world's store of knowledge, to enter the ranks of teachers, or to assume the duties of the learned professions. It is to the lives of these few that the university looks for her greatest share of reflected honor, and the state for her highest grade of professional men. It is for the encouragement and

advancement of these exceptional students, who are to be intellectual leaders in after life, that the university may reasonably be asked to extend special consideration and assistance during the continuance of their graduate studies.

This would seem to be the highest function of the university, not only because it encourages her best students to strive to attain the higher walks of intellectual life, but because in the process of discovering the man or woman of exceptional ability all her sons and daughters are encouraged to advance to the highest plane their mental endowments permit them to reach.

The place for research work in the university is, then, at the close of the courses of study pursued in her several colleges; that is, in the graduate school, to which only those students who have successfully passed their final college examinations and received the bachelor's degree are admitted. The graduate school might well be named and made in fact the *school of research*. Without such a school a group of colleges should not be classed as a university. As expressed by Hon. Seth Low, in an article on 'Higher Education in the United States,' published in the *Educational Review*, 'The work of the college is to teach that which is already known—the work of the university is, in addition to this, to enquire, to ascertain what lies beyond the line that marks the limit of the known.' In the school of research, the leading idea being the development of originality, it is evident that the professors should be chosen from the ranks of those who have won distinction on account of their original contributions to the branch of knowledge in which they presume to serve as guides. In the school of research, also, professor and student should be coworkers and mutually assist each other. From such comradeship, that intangible something which is transmitted from person to person by association and contact, but can not be written or spoken—we may term it inspiration, or personal magnetism, or perhaps the radium of the soul—is acquired by the student in a greater degree than at any previous time in his life after leaving the caressing arms of his mother. In the school of research professor and student should have the time and facilities their work demands. From such schools, as may reasonably be expected, will come in the future the best trained men and women and the greatest contributions to human knowledge.

Seemingly, all college-bred men must recognize the demands of higher education, every captain of industry appreciate the commercial benefits flowing from an increase in knowledge, and every citizen see that the search for truth is the best method of enhancing morality and integrity and of elevating the human race. The interests of all branches of society are thus primarily centered on research. There is a *demand* that progress be made and that the utmost attainable bounds of the knowable be reached.

Demands of men trained in the law, in medicine, in engineering, etc., have led the trustees and regents of universities to establish and maintain professional schools, and not only the number of men entering the learned professions, but their efficiency, has been increased thereby. As I have endeavored to make clear, there is also a demand which is urgent and pressing, for men who can carry on research work in pure science, and who are qualified to discover new facts, new laws and new forces to be utilized in industry. This demand also deserves to be met by our state universities, in order that the best possible returns may be made to the citizens of a state who, by taxing themselves, support such institutions. While the direct economic returns to be expected from the es-

tablishment and adequate maintenance of research schools at public expense would amply justify such a course, such promises do not stand alone, as research, to use the words of Lockyer quoted above, is the most powerful engine of education known.

The undertakings of communities, as is well understood, are formulated and guided by a comparatively few individuals who see not only the immediate and tangible ends to be gained, but the far-reaching influences that follow. It is from these few informally appointed directors of communities that I venture to ask for due recognition of the fundamental importance of research, both as a means for securing greater returns from commercial pursuits and higher educational training in our universities. When these truths are fully appreciated and clearly expressed by the leaders of communities, the keystone will be placed in the educational arches states have erected, and the continued advance of our country and the attainment of a still greater degree of human happiness be assured.

Israel C. Russell.

University of Michigan.

SCIENTIFIC BOOKS.

Grundlinien der anorganischen Chemie. Von Wilhelm Ostwald. Zweite, verbesserte Auflage. Leipzig, W. Engelmann. 1904. Pp. xx + 808.

The first edition of this book appeared in 1900, and in the course of three years the entire edition of four thousand copies was exhausted. In addition, translations into English and Russian have appeared which have also had a large sale. A translation into French is in course of preparation.

The second edition differs but very slightly from the first. The first half of the first chapter has been rearranged somewhat to secure a clearer presentation of general fundamental conceptions; but aside from this, practically nothing has been done except to correct minor errors appearing in the first edition.

The general plan of arrangement and treatment of the subject matter of this book was sufficiently elucidated in the pages of Science when the first edition appeared. The new departure represented by this treatise consists in an attempt to incorporate systematically the conception of mass action, the phase rule and, in general, the hitherto much neglected influence of temperature, pressure and concentration, as vital factors in determining the progress of chemical reactions. This feature of the treatise together with the constant endeavor of the author to develop ideas inductively and to connect with the substances studied their various important physical and physiological as well as chemical properties, constitutes the valuable, if not the epoch-making part of the book and justifies the remarkable sale of the first edition, which clearly indicates that chemists generally have gladly embraced the opportunity afforded to become acquainted with this new method of presenting elementary chemistry.

On the other hand, the introduction of the 'ions' as a purely chemical conception is unfortunate. While there might possibly have been a justification to thus introduce this conception at the time the first edition was written, the unqualified retention of this notion in the second edition can not be justified; for, since the appearance of the first edition, it has been demonstrated that instantaneous chemical reactions occur in the best of insulators exactly as they do in electrolytes. The use of the term ion in the 'purely chemical' sense as it appears in this book must now be considered merely as a mode of speaking, the term signifying only what has hitherto been expressed by the word radical.

The descriptive part of this book is not unlike that of other books of similar scope, except for an additional remark here and there about ions of this or that kind. Indeed, in most instances Ostwald writes reactions as they have always been written, without using the ionic notation; in so doing he virtually admits that it is not feasible to apply the ionic conceptions logically in most cases. Such an attempt would, indeed, often lead to grotesque distortions rather than to a simple mode of expression which every one could understand.

The weak part of the treatise, then, consists in the undue magnification of the importance of the analogy between gases and solutions and the unsuccessful attempt to make the ionic conception the basis of explaining chemical reactions. To eradicate these undesirable features will necessarily cause a somewhat profound change in the character of the book. The author has everywhere deliberately chosen to entirely omit 'in the interests of the student' a consideration of opinions which conflict with his own. This course can hardly be justified by the additional care which, it is stated in the preface, was exercised in the choice and exposition of the ideas presented, and will only make it all the more difficult to introduce the changes which sooner or later must be made in future editions of the book if it is to continue to be of real value.

LOUIS KAHLENBERG.

SOCIETIES AND ACADEMIES.

THE SAN FRANCISCO SECTION OF THE AMERICAN MATHEMATICAL SOCIETY.

THE fifth regular meeting of the San Francisco Section of the American Mathematical Society was held at Stanford University on April 30, 1904. Twelve members of the society were present. A morning and an afternoon session were held. Both these sessions were attended by a number of local teachers of mathematics who are not members of the society. The following papers were read:

PROFESSOR M. W. HASKELL: 'The construction of conics satisfying given conditions.'

PROFESSOR H. C. MORENO: 'On a class of ruled loci.'

DR. D. N. LEHMER: 'On a cylinder the intersection of which with a sphere will develop into an ellipse.'

MR. A. W. WHITNEY: 'The application of actuarial methods to fire insurance.'

PROFESSOR R. E. ALLARDICE: 'On the envelope of the directrices of a system of similar conics through three points.'

PROFESSOR IRVING STRINGHAM: 'Analytical treatment of certain metrical relations in the non-euclidean plane.'

PROFESSOR G. A. MILLER: 'Addition to a theorem due to Frobenius.'

PROFESSOR H. F. BLICHFELDT: 'A theorem concerning the invariants of linear homogeneous groups with some application to substitution groups.'

PROFESSOR H. F. BLICHFELDT: 'The linear homogeneous groups in four variables.'

PROFESSOR M. W. HASKELL: 'Triangles in perspective and the collineations derived therefrom.'

PROFESSOR M. W. HASKELL: 'The construction of a twisted cubic from six points.'

In the absence of Mr. Whitney his paper was read by Professor Stringham. The next meeting of the section will be held at California University on October 1, 1904.

G. A. MILLER,
Secretary.

MINNESOTA ACADEMY OF SCIENCES.

THE meeting of the academy was held in the geological lecture room of the University of Minnesota, on April 11, when the following paper was presented: 'The Gypsum Deposits of New York State,' by Mr. A. L. Parsons, instructor in geology in the University of Minnesota, illustrated by lantern slides.

Through the courtesy of Dr. Frederick J. H. Merrill, director of the New York State Museum, Mr. Parsons was enabled to present the results of his studies on the geology and economic importance of the gypsum deposits of New York before their publication as a state report. These deposits, which were among the first to be discovered and developed in this country, are in the rocks of the Salina age and are closely related to the salt deposits of the state. All the mines of importance are located in a shallow valley extending from Rome to Buffalo, and east of Rome the deposits, though of no commercial importance, are found on the south side of the Mohawk Valley as far east as Schoharie.

The formation of this valley occurred prior to the glacial epoch, and in the region between Syracuse and Rome it has been filled with several hundred feet of glacial and alluvial débris. The presence of this valley is explained by the wearing away of the soft Salina shales and soluble beds of salt and gypsum which lie between the harder limestones of the Niagara and Helderberg periods. With the development of the cement wall plaster and

the Portland cement industries these deposits, which up to that time were used only as a source of land plaster, have become of great importance as a source of plaster of Paris; and, although it is not as pure as Nova Scotia gypsum, it finds a ready market as a wall finish. Plaster of Paris is used at present in place of lime plaster as a wall finish on account of its quick setting, so that the buildings may be occupied without delay. It is also extensively used in the manufacture of Portland cement to retard the set, and, if not more than two per cent is used, it adds materially to the final strength. The manufacture of plaster of Paris depends upon driving off part of the water from gypsum, care being taken not to expel all the water, in which case the plaster fails to set. The hydrate formed in this way is known as plaster of Paris and has the property of again combining with as much water as has been driven off and forming a hard network of fine crystals, or, as it is called technically, the property of setting. The present processes of manufacture were then described, and an historical sketch of primitive and former methods was given.

Mr. Wm. A. Bryan, ornithologist of the Bishop Museum, Honolulu, described the work he was doing in cataloguing and describing the academy's Menage collection of birds of the Philippine Islands. This collection of over 4,500 birds was made by D. C. Worcester and F. S. Bourns in 1890–93, and was the best source of material for Mr. Bryan's purpose of working up all the birds of Polynesia as he has already done for the Hawaiian Islands.

H. GALE,
Secretary.

THE GEOLOGICAL SOCIETY OF WASHINGTON.

AT the 156th meeting, held April 27, 1904, Mr. N. H. Darton presented a paper on 'Salt Lake South of Zuni, New Mexico,' illustrated by stereopticon. Mr. Darton described the topography and geology of this interesting lake basin, and presented various theories for its origin. His paper will shortly be published in full.

Mr. George H. Ashley then discussed the plain around Middlesboro, Ky., and its relation to the Appalachian structure of the region. A study of the general structure shows a differential yielding of the strata at this point to the tangential stresses that produced the deformation of the Appalachian province. This brought about transverse faultings with horizontal shearing, buckling, and in the shale around Middlesboro highly confused folding, possibly associated with a local downward flexure of the heavy Lee sandstone. The plain is the result of ponding, and a careful study of all the facts seems to indicate conclusively that to produce this ponding there has been recent movement along the old fault planes, or folds, or both. This movement has been at least one hundred and possibly several hundred feet vertical, and is possibly post-Tertiary in age.

The next paper, entitled 'The Significance of U-shaped Glacier and Stream Channels,' was by Francois E. Mathes.

The tendency to assume a U-shaped cross-section is not characteristic of glacier channels alone, and should not be looked upon as the peculiar result of ice action. Channels produced by streams of water exhibit the same tendency, and this type of cross-section should, therefore, be considered characteristic of all stream-worn channels, using the term stream in its broadest sense.

Observation on irrigation canals and ditches teaches that whatever their original cross-sections may be, they will in time be replaced by U-shaped ones. The transformation may be affected: (1) by enlarging, that is by cutting alone, (2) by cutting and filling combined, or (3) by filling alone. The resultant figure is the same in each case, provided the volume and the slope are the same. It further appears that after certain definite proportions of outline have been reached the cross-section no longer tends to change but remains virtually stable so long as the conditions of flow remain unchanged. It is inferred from this that a stream of constant volume, flowing on a uniform slope, tends to evolve a cross-section of certain definite proportions, this cross-section being the one through which the stream can flow with the greatest economy, that is to say,

with the least resistance. This may be termed the normal cross-section.

The shape of this normal cross-section is expressive of a well-ordered interior arrangement of the flowing mass; in other words, it indicates a definite organization of the stream. All streams should be considered as constantly endeavoring to organize; the more efficient their organization, the more economical their flow.

An analysis of the mode of flow was advanced many years ago by D. T. Smith in an essay on the 'Law of the Double Helix.' This theory was briefly outlined as not only affording a probable explanation of the manner of organization, but also satisfactorily accounting for the tendency to produce normal cross-sections of the shape described.

Whether this theory be accepted or not, the fundamental principle of organization stands unchanged. The tendency to evolve normal cross-sections is alone sufficient to establish it.

The application of this principle to the study of stream and glacier channels could not be considered for lack of time.

ALFRED H. BROOKS,
Secretary.

THE BIOLOGICAL SOCIETY OF WASHINGTON.

THE 386th regular meeting was held on Saturday evening, April 16, 1904. Carleton R. Ball exhibited specimens of the dead nettle (*Lamium amplexicaule*) showing cleistogamous flowers which are produced abundantly in early spring. Later in the spring the large elongated open flowers are produced and the cleistogamous form disappears.

William R. Maxon spoke on 'Some Termite Nests of Jamaica,' describing three nests collected for the Smithsonian Institution in the vicinity of Hope Gardens, Jamaica, in the spring of 1903, and giving general notes (illustrated by photographs) on the occurrence and habits of *Eutermes ripperti*, the most common species of the island. Occupied nests, being the most perfect, were secured by poisoning several colonies of the insects. The nests secured were all of this species, which occurs abundantly in the lower dry limestone hills up to an altitude of 2,000 feet. They are built without much discrimination upon the ground, in trees, upon old logs, walls, etc. The exterior of the nest consists of a thin granular, delicate fluted covering, very much more delicate than the darker honeycombed interior portion and very readily separable from it. The largest of the nests collected was exhibited, and also a queen cell and alcoholic specimens of queens, workers, nasuti and other forms of the insects. Notes on the life history of *Eutermes ripperti* contributed by E. A. Schwarz were also read.

Vernon Bailey spoke on 'A Simple Method of Preserving Tracks'; and exhibited a specimen of a mold of a wolf's track. A fresh track of a wolf was found in moist sand and melted paraffin from an ordinary candle was poured into it, producing a characteristic mold.

E. S. Steele gave an account of an investigation approaching completion of the globose-headed *Laciniarias, i. e.*, of the group of plant species which have been included under the name *Laciniaria* (or *Liatris*) *scariosa*. The investigation has had the benefit of ample material, comprising, besides that contained in the National Herbarium, numerous loans from institutions and individuals, and representing the territory from Maine to Florida, Texas, the Rocky Mountains and Saskatchewan, the Minnesota region being specially rich. Reference was made to the few hitherto published names applicable to this material. The characters upon which group and specific distinctions must turn were noted and illustrated by drawings, the involucral bracts and the foliage being the most important. The species, of which there were declared to be not less than sixty, were stated to fall into three fairly distinct groups. Mounted specimens of a number of the species were exhibited.

E. L. Morris read a paper on the 'History and Knowledge of the Bush Morning Glory and its Reproduction.' The species was first collected in 1820 and reported as annual. Later it was collected many times, and occasionally with enormous perennial roots which sometimes weighed as much as 200 pounds. Its reproduction is commonly by seed, but another method was mentioned not before re-

ported for the species, namely, the production of lateral root-shoots from the upper part of the narrow roots near the surface of the soil. These root-shoots at a favorable opportunity produce a bud which develops into a new plant. Drawings and specimens were presented to illustrate the paper, which will be published in full in the *Plant World*.

WILFRED H. OSGOOD,
Secretary.

THE CORNELL SECTION OF THE AMERICAN CHEMICAL SOCIETY.

THE Cornell Section of the American Chemical Society closed the second year of its existence on May 3, when officers for the coming year were elected. An additional meeting will occur on May 31, at which the retiring president, Professor W. D. Bancroft, will give his president's address. He will discuss the theory of electroplating, and will illustrate his remarks by experiments.

From the first meeting of the Cornell Section in December, 1902, it has grown in numbers and interest. Seventeen new members have been added during the past year and at the present date there are forty-three members all told. A peculiarity of the Cornell Section is that its life and work are centered so entirely within the Cornell University Department of Chemistry. Of its members twelve are undergraduate students; seven, graduate students; and twenty-two, members of the staff of instruction of Cornell University. Two are connected with the Agricultural Experiment Station at Cornell.

The meetings of the year have been well attended and considerable interest has been evinced in original work. Eight sessions were held, with an average attendance of twenty-four members and twenty-five visitors. Eight papers, giving the results of research in the department, were read and discussed.

Dr. J. E. Teeple presented a paper on 'Bilirubin, the Red Coloring Matter of the Bile,' and another on 'The Electrolytic Preparation of Iodoform and Chloroform.' Mr. E. S. Shepherd presented 'An Apparatus for the Electro-deposition of Metals using a Rotating Cathode.' Mr. J. M. Bell discussed the 'Vapor Pressure of Tobacco.' Mr. F. C. Robinson gave a description of 'A New Boiling Point Apparatus.' Dr. H. R. Carveth discussed the data obtained from a study of distillation, boiling point methods of molecular weight determination, and vapor composition. Dr. A. W. Browne presented some data and conclusions from experiments performed elsewhere in conjunction with Dr. W. P. Bradley on the 'Resistance of Glass Tubes to Bursting Pressure.' Mr. I. Baum read a paper which was produced in collaboration with Mr. F. J. Schwab, on 'Electrolytic Copper Refining.'

Aside from this original work the section has enjoyed several interesting addresses. Professor G. W. Cavanaugh outlined the 'Applications of Chemistry to Modern Agriculture.' Mr. J. A. Bonsteel gave a résumé of the work of the United States Soil Survey. Professor E. L. Nichols and Professor E. Merritt jointly gave an address on 'The Behavior of Indicators at Low Temperatures,' which they illustrated by experiments. Dr. E. M. Chamot discussed the results of the examinations of Ithaca waters during 1903. Dr. W. R. Orndorff lectured on the history and development of 'The Manufacture of Indigo from Coal Tar.'

The most notable meeting of the year was addressed by Professor Ernest Rutherford, of McGill University, on 'The Emanations of Radium.' His experimental lecture was enjoyed by a large audience of students and others interested in radioactivity.

The Cornell Section begins the next year with the following officers:

President—Professor E. M. Chamot.

Vice-President—Dr. J. E. Teeple.

Secretary-Treasurer—Mr. F. C. Robinson.

Executive Committee—The above officers *ex-officiis* and Dr. H. R. Carveth, Mr. W. S. Bishop and Professor W. R. Orndorff.

Councilors—Dr. G. C. Caldwell and Professor L. M. Dennis.

WILLIAM C. GEER,
Secretary.

THE NEW YORK ACADEMY OF SCIENCES.
SECTION OF GEOLOGY AND MINERALOGY.

THE section held its regular meeting Monday evening, April 18, with the chairman, Professor James F. Kemp, presiding. The

evening was principally devoted to a paper by Dr. Arthur Hollick, of the New York Botanical Garden, entitled 'A Canoe Trip down the Yukon River from Dawson to Anvik.'

Dr. Hollick said in brief: The trip was made under instructions from the United States Geological Survey, with the special object of collecting paleobotanical material, from which to determine the age of certain exposures in central Alaska.

The party consisted of Dr. Hollick, Mr. Sidney Paige, field assistant, and Mr. John Rentfro, cook and general camp assistant. The start was made from Seattle, Wash., on June 1, 1903, by steamer to Skagway, Alaska, where they arrived on June 5 and remained until June 11, waiting for the ice to break up in the Yukon River. On June 11 the route was by railroad to Whitehorse, Yukon Territory; June 12–15, by steamboat down the upper waters of the Yukon to Dawson, Yukon Territory, where a nineteen-foot Peterborough canoe was purchased and the trip down the river begun. The trip was ended at Anvik, Alaska, August 12, after about 1,100 miles of the river had been explored and about 1,800 pounds of specimens had been collected and shipped. The highest point north was reached at Fort Yukon, July 2, just beyond the Arctic circle.

The Yukon River occupies what was until quite recently a broad estuary. Subsequent elevation of the land resulted in the draining of the estuary and the formation of the present river valley, which has cut its way down through the estuary deposits, leaving these as broad benches or terraces. Mastodon and other remains of extinct animals indicate the Pleistocene age of the deposits. One of the finest exposures is at the 'Palisades,' just below Rampart.

The width of the river varies from one to ten miles, and the main channel is constantly shifting. It pursues a meandering course, sometimes impinging on one side of the old valley, sometimes on the other; but for long distances it flows through the middle. Where it occupies the latter position, it is generally broad, with a current of about four miles per hour, and filled with innumerable wooded islands, mud flats and sand and gravel bars, which render navigation more or less a matter of guesswork, on account of the impossibility of telling where the main channel may be and the liability of running into a blind slue or long circuitous channel around an island. It was often found advisable to climb up the river bank to a considerable elevation in order to determine, by means of an extended view, where the correct course lay. Where hard rocks were exposed along the river banks, or a short distance away, these were subjected to careful examination in regard to their lithologic, paleontologic and stratigraphic characters.

Amongst the interesting results obtained were: (1) the determination of the Tertiary age of certain sandstones above Rampart; and (2) the determination of the Cretaceous age of other sandstones and shales further down the river in the vicinity of Nulato. At one locality, a unique fossil flora was found, totally different from any heretofore known in America, consisting of cycads of Lower Cretaceous types, mixed with angiosperms belonging to what have always been considered Upper Cretaceous types.

Only a preliminary study has been made of the material collected, which will eventually be carefully examined and reported upon for the United States Geological Survey.

The paper was illustrated with about seventy lantern slides, showing the principal topographic and geologic features of the route.

The Grand Soufrière of Guadeloupe, an Analogue of Mont Pelé: EDMUND OTIS HOVEY.

Dr. Hovey showed twelve lantern slides illustrating the Grand Soufrière of Guadeloupe, and stated that the field evidence indicated that the present active cone of this volcano was closely analogous to the new cone and spine of Mont Pelé, Martinique, that is to say that it had been pushed up bodily into its present position, or had welled up through the conduit in such a viscous condition that contact with the atmosphere rendered it too rigid to flow. At the base of the cone on the north there is a gently rising flat area, apparently the segment of a circle indicating the position

of a part of the rim of a crater in existence before the construction of the present cone.

The map shown in connection with the paper was prepared by M. Léon Leboucher for the Club des Montagnards of Guadeloupe. This club has recently celebrated the first anniversary of its founding, and its report shows that it has done a great deal in a short time toward the opening up of roads and paths to the Soufrière, making the highest and one of the most interesting mountains of the Lesser Antilles readily accessible to visitors.

EDMUND OTIS HOVEY,
Secretary.

DISCUSSION AND CORRESPONDENCE.

THE METRIC SYSTEM.

TO THE EDITOR OF SCIENCE: Permit me to differ from Mr. William Kent as to the conclusion to be drawn from Professor W. Le Conte Stevens's article on the metric system. If he will substitute for the word 'impossibility' the word 'possibility' I shall be glad to agree that Professor Stevens's 'article is useful, however, in showing the possibility of the general adoption of the metric system in its present form by the people of this country.' There seems to be every probability that one will not have to live to be very old in order to see by experience this possibility become a fact, in this country as well as in England, which now seems likely to precede us in this reform, as she has in various political ones. I can not share the desire of Professors Lane and Stevens to temper the metric system to the conservatism of the American people by adopting its values disguised in the sheep's clothing of the present non-system. I believe that the intelligence of our people is not insufficient to enable them to drink their milk by the liter with as much gusto as by the quart, and to realize that six cents a liter is six dollars a hectoliter, even if a Greek prefix is involved. It takes a bold man to assert that the American people can not do what the French and Germans have done, and that they will not be able to see the advantage of it. If 'the people can not be compelled to adopt a nomenclature that is thrust upon them as a substitute for that to which they have always been accustomed' we should have no decimal system of currency to-day, for the people were very much accustomed to pounds, shillings and pence, but seem to have been willing to be compelled to adopt dollars and cents (what an outrageous, foreign, difficult Latin word!), and in fact, seem even to prefer them. Is the inch more sacred than the pound? The engineer will reply, yes, and here we come to the kernel of the whole matter. It is the mechanical engineers and builders of machine tools who are delaying the adoption of the metric system. Now, while these persons constitute a very important part of the community, they do not constitute the whole of it. Drills, taps and dies, rigs and jigs are not the only argument that should be brought into the question, although engineers would have us believe it. Of course, it will cost us something to change our system, and this is a visible item. It is costing us more not to change it, but this is not so visible. I do not care to go into the arguments here, but merely to protest against the argument from conservatism, and also to suggest that the best way to find out the facts about the metric system is to apply, not to the engineers, who have not used it, but to the scientific men who have used it. The attitude of the conservative engineer toward changing the system of measurement is very similar to that of Cæsar toward the Senate: 'Can not is false, and that I dare not, falser; I *will* not' change.

ARTHUR GORDON WEBSTER.

ZOOLOGY AND THE INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE.*

This work has just come into my hands and I have examined it for references on the subject to which most of my attention is given, viz., Cœlenterata. The data given below will indicate the value of the catalogue, so far as Cœlenterata are concerned, in comparison with two other well-known bibliographic undertakings, the 'Bibliographia universalis' of the Concilium Bibliographicum and the *Zoological Record.*

For the year 1901, the Concilium Biblio-

* 'The International Catalogue of Scientific Literature.' First Annual Issue, N, Zoology [for the year 1901]: 1904 (February).

graphicum has 155 entries (omitting 3 that should be credited to 1902, and adding one erroneously dated 1902). The *Zoological Record* for 1901 contains 153 titles. Of these 1 (54)* is for 1899; 11 (36, 39, 42, 44, 78, 117, 124, 128, 134, 140, 141) for 1900; and 1 (92) belongs to 1902, leaving 140 for 1901. The volume for 1902 furnishes 5 for 1901.

The 'International Catalogue' for 1901 contains 92 references, at least 3 of which belong to 1902, leaving 89.

There are in my own card catalogue for 1901 222 entries. Of these:

	Entries.
The Concilium Bibliographicum published	155
The *Zoological Record* for 1901 adds	54
The 'International Catalogue' for 1901 adds	7
Collected by myself and not in any of the preceding	6
	222

The Concilium Bibliographicum procured 70 per cent. of the references; the *Zoological Record* for 1901† 63 per cent.; and the 'International Catalogue' 40 per cent.

Thus it will be seen that the 'International Catalogue' contains less than half the references on this subject, and that two other far superior bibliographies are being published.

It is scarcely necessary to cite specific omissions. Works of importance published in practically every country are left out, England, Canada, Australia, the United States, Russia, Germany, etc. If other zoological subjects can be judged by the Cœlenterata, to make the 'International Catalogue' of any special value the work must be done much more thoroughly, and should appear with reasonable promptness.

T. WAYLAND VAUGHAN.

WASHINGTON, D. C.,
May 13, 1904.

NON-EDUCATION OF THE YOUNG BY PARENTS.

SOME of our new nature students appear to think that it is necessary that the young of animals should be taught to take care of themselves by their parents, or, at least, that they shall learn by example. While glancing over some of the controversial articles on the subject that have lately appeared, some cases that bear directly on the question came up to memory.

There are a few 'annual' fishes whose entire cycle of life is performed within a year. Professor Robert Collett, of Christiania, in 1878, recorded the biographies of a couple of those which are quite common in Europe. They belong to the family of gobies or gobiids and are the *Aphya pellucida* and *Crystallogobius nilssonii*.

Although very distinct in their generic as well as specific characters, they agree in their physiological characteristics. From June to August they are at the height of their sexual maturity and males are trenchantly differentiated from females. After spawning they 'seem always to keep together in enormously large shoals' and are the easy victims of innumerable other fishes, large and small. Before winter supervenes they are supposed to have all died off; 'it is probable that no specimen lives more than one year and after the close of the breeding-time [everyone] dies without living through another spawning; consequently, these fishes are really annual vertebrates.' The species as represented by adults become extinct annually and are only represented by eggs. Where then are the teachers or exemplars?

A more familiar group of fishes furnishes us with an analogous case of death after spawning, though perhaps less striking than that of the annual gobiids; that group is the genus *Oncorhynchus,* including the hook-nosed salmons of the west coast. All the American species—five in number—have their alimentary canal so shrunken and defunctionalized soon after their entrance into fresh water that they can not assimilate food, and besides they literally become worn out and used up, so that soon after spawning and milting they die; not one lives to go to salt water and return to fresh again. Consequently the young can not have the benefit either of parental instruction or of learning through

* These numbers in parentheses are those prefixed to the papers in the list of titles of the *Zoological Record.*

† The additions made in 1902 are not included in calculating this percentage.

association with their elders. Where now are the teachers and exemplars?

THEO. GILL.

PRICE OF THE REPORTS OF THE HARRIMAN EXPEDITION.

I DESIRE to correct an error in my review of volumes three and four of the Harriman Expedition, published in the preceding number of SCIENCE (May 2, 1904). As I have been informed, the price which I quoted from a trade-list of the publisher applies to volumes one and two of the series and not to subsequent volumes. The price of volumes three and four, the ones reviewed, is $5.00 per volume.

ISRAEL C. RUSSELL.

SPECIAL ARTICLES.

AN ENEMY OF THE COTTON BOLL WEEVIL.

SPECIMENS of the cotton boll weevil were obtained in eastern Guatemala in 1902, during a visit made to that country in order to study the culture of coffee and rubber, for the United States Department of Agriculture. The insects, which were collected on the request of the Division of Entomology, were not found on the cotton cultivated by the Indians, but were very common in the flowers of the tree cotton growing spontaneously near a native house, a short distance from the cotton field. The beetles were secured in a rather inaccessible part of Alta Vera Paz, seldom visited by naturalists or other travelers. It lies between Cajapon and Sepacuite, and is inhabited only by primitive Indians and a very few Spanish-speaking 'natives' of mixed blood.

The Indian variety of cotton seemed very small and unpromising, only one or two bolls being borne on a plant; it seemed very strange also that so small a variety should be planted while the large tree cotton was so ready at hand. It was learned, however, from Mr. Kensett Champney, who has a most thorough acquaintance with the agricultural habits of the Indians, that this was the only variety of cotton planted by them in this district, and the one exclusively relied upon to furnish material for their native fibers. The absence of the weevils from the small Indian cotton was reported when the specimens of the beetles were brought back to Washington, but the diminutive size of the plant seemed to forbid any recommendation of profitable utility in the United States.

Later on, with the increasing acuteness of the boll weevil question and the voting of a special appropriation by Congress for the study of means of protection against its ravages, the existence of a variety of cotton in Guatemala which seemed not to be subject to the attacks of the boll weevil was recalled, and it seemed to the authorities of the Bureau of Plant Industry that every clue should be followed up. The Secretary of Agriculture authorized an investigation of the Indian cotton of Alta Vera Paz, to ascertain whether it possessed, in reality, any quality enabling it to resist the boll weevil, or to learn other causes of its immunity from the attacks of the insect. The custom of the Indians to plant their crops every year in tracts of land recently cleared by burning suggested an alternative possibility that if not actually resistant to the weevil the cotton might have an almost equally valuable tendency to quick growth, thus enabling a crop to be obtained before the weevils had time to become injuriously numerous. The importance of securing early varieties has been emphasized as the result of the investigations of the boll weevil in the United States.

In this part of Guatemala the present season has been much more rainy that that of 1902, and the cotton is much larger. Well grown plants bring to maturity from ten to twenty bolls of fair size, and even more. A thorough search shows that the weevil is present and able to injure the cotton, but reveals also an active enemy which keeps it in check. This is a large reddish brown ant which is attracted to the cotton by the food which it secures from three sets of extra-floral nectaries. Each leaf has a nectary on the under side of the midrib, from one to two centimeters from the base. Each of the large bracts of the involucre has a circular or broadly oval nectary close to the stem, and there is a third series of three nectaries at the base of the calyx, between the pair of small bracts alternating with the larger divisions of the involucre, of which

they seem to be, morphologically speaking, the stipules. Nectar is also to be found between the calyx and corolla, but no bees, flies, or other winged insects were observed visiting the flowers except beetles, sometimes the boll weevil, but much more often a small black staphylinid of very active habits. To these and to the very small black ants which are also occasionally present in numbers on the cotton, the large brown ant pays no attention, but the weevil is attacked on sight and becomes an easy prey.

The ant's mandibles are large enough to grasp the weevil around the middle and pry apart the joint between the thorax and abdomen. The long, flexible body is bent at the same time in a circle to insert the sting at the unprotected point where the beetle's strong armor is open. The poison takes effect instantly; the beetle ceases to struggle, and with its legs twitching feebly is carried away in the jaws of its captor. As with many other insects when stung by wasps the paralysis is permanent; even when taken away from the ants the beetles do not recover. The adroit and business like manner in which the beetle is disposed of, in very much less time than even the briefest account of the operation could be read, seems to prove beyond question that the ant is by structure and by instinct especially equipped for the work of destruction, and is, in short, the true explanation of the fact that cotton is successfully cultivated by the Indians of Alta Vera Paz, in spite of the presence of the boll weevil. Instead of congregating in large numbers on the cotton in the immediate vicinity of their nests the ants have, as it were, the good sense to spread themselves through the field, from 2 to 4 or 5 usually being found doing inspection duty on each plant. In some places there seemed to be not enough ants to go around, and here the beetles were more numerous. Rarely, too, certain flowers or branches seemed to have been overlooked, beetles being found on the same plants with the ants. In such instances, indeed, the young flower or boll was generally riddled with punctures as though many beetles had availed themselves of the rare opportunity of feeding undisturbed.

Cotton-growing among the Indians is something of a special art, the community being supplied by a few men aware, as it were, of the secrets of the business. They know nothing about the weevil and its ravages, and ascribe such damage as occurs to other harmless insects, or even to superstitious causes, such as the failure of the owner to abstain from salt at the time of planting. The ant, however, is definitely associated in their minds with cotton, and they do not expect to secure a good crop unless these insects favor the plants with their presence. Some of the Indians give the ant a special name, *kelep*, not applied to any other species, but it is also referred to as 'the animal of the cotton.'

In the neighborhood of Secanquim, on the coffee estate of Messrs. Champney and Company, where the most of our observations have been made, the ants are by no means widely distributed, and the cultivation of cotton is confined to very narrow limits, where it is planted year after year in closely adjacent places, or even on the same ground. In one instance the same Indian has planted cotton on the same hillside for upwards of forty years, with no failure to secure a crop except in one year, as he explained, when he was sick and did not sow! Such facts preclude, of course, any explanation based on the theory of temporary immunity secured from burning over the land or by planting in a new place in which the beetles have not had time to congregate. The cotton is sowed in October or November, a very rainy part of the year, when land can not be cleared by burning, and the weeds are pulled out and thrown with the dead corn stalks and brush into piles, which would protect the beetles rather than destroy them. The perennial tree cotton also furnishes permanent breeding-places, so that the conditions are most favorable to the propagation of the beetles in large numbers. The ants, however, are evidently able to hold them in check, and thus permit the regular cultivation of an annual variety of cotton by the Indians.

Ethnological data show that the weaving of cotton cloth was practised in tropical America for many centuries before the arrival of

Europeans, and the probability is great that the plant itself is a native of this hemisphere. In being carried to other countries it was taken beyond the reach of both the friends and the enemies which had developed with it. The boll weevil has migrated northward with the extension of the area of cotton cultivation into Mexico and Texas, but the ant has not yet followed. The question now is whether it can be induced to do so. The Mexican entomologists seem not to have found the ant in that country, in the northern states of which the weevil has been reported as very destructive.

That the ants are so localized in their distribution in this part of Guatemala has undoubtedly served the better to demonstrate their value as protectors of the cotton plant; it suggests also, with other facts, the probability that they are not native here, but have spread eastward in smaller or larger colonies as the forests were cleared away by the Indians. The present occupation of the eastern districts of Alta Vera Paz by the Indians does not date back more than a few generations, though abundant evidence of much more ancient inhabitants is found in the apparently primeval forests. The ants, like the Indians, probably came from the dry, open interior plateau region, where the center of the aboriginal cotton industry of Guatemala is still located, and where another visit to the ants is to be paid in the next few days. To establish such an origin for this useful insect would greatly increase the probability of its successful introduction into the United States. The acclimatization of a thoroughly tropical animal requiring continuous heat and humidity could scarcely be hoped for. If, however, the cotton ant can survive a long dry season and perhaps cold weather in the table lands of Guatemala it might easily learn to hibernate in Texas, as has the boll weevil. The ant, indeed, is much better able to protect itself against frost, since it excavates a nest three feet or more into the ground. That it is a reasonably hardy insect is shown also by the fact that several individuals have survived confinement for twelve days without food, and seem now to be thriving on a diet of cane juice. To take worker ants to Texas will be, evidently, a very easy matter, but to secure queens and establish permanent colonies may require considerable time and experiment, and a thorough study of all the habits of the species.

Although the cotton seems to be especially adapted to attract the ant by means of its numerous nectaries, the insect is not, like some of the members of its class, confined to a single plant or to a single kind of prey. It was observed running about on plants of many different families, and it attacks and destroys insects of every order, including the hemiptera, and even centipedes. On the other hand, it does not do the least injury to the cotton or to any other plant, as far as has been ascertained, and it can be handled with impunity, having none of the waspish ill-temper of so many of the stinging and biting ants of the tropics. Since where once established it exists in large numbers and seeks its prey actively, it is a much more efficient destroyer of noxious insects than the spider or the toad. It seems, in short, not unlikely to become a valued assistant in the agriculture of tropical and sub-tropical countries, if not in temperate regions. The farmer has a new and practical reason to 'consider the ant.'

An accumulation has been made, of course, of seeds, specimens, photographs and notes bearing on the cotton, beetles, ants and many other collateral matters not to be mentioned here. Even this brief preliminary report should not close, however, without an acknowledgment of the many favors of Messrs. Owen and Champney, owners of the Sepacuite estate, and of Mrs. Owen. Without the kind invitations, hospitality and extensive local knowledge and cooperation of these generous friends, it would have been quite impracticable to visit the Indian cotton district of the interior of Alta Vera Paz in 1902, or to ascertain the existence of the cotton ant in the present season. O. F. Cook.

Sepacuite, Guatemala,
May 11, 1904.

ZYGOSPORE FORMATION A SEXUAL PROCESS.

In a paper now in process of publication the writer has given a detailed account of a

somewhat extended investigation on the method of reproduction in one group of the common molds, and since many of the facts which have been discovered are at variance with the conclusions of other investigators, and since the problems involved have a general biological interest, it has seemed desirable to publish the following preliminary summary of the more important results obtained.

Among the Mucorineæ, as is well known, the usual form of reproduction is by means of non-sexual spores in sporangia, while the sexual method by means of zygospores is unknown in the great majority of species, and even where it has been reported our knowledge of its occurrence in about four fifths of the cases is based on the recorded observations of single individuals. For over thirty years the phenomena of reproduction by zygospores in these plants have been an object of considerable investigation among students of fungi, and as a result a number of conflicting theories have arisen as to the significance of the process and the conditions by which it is induced. Such conclusions as have been reached have in general been based on the assumption that external conditions of one kind or another were the essential factors concerned, and, while the process has been generally regarded as a primitive type of sexual reproduction, some investigators have denied that any sexuality is involved in zygospore formation.

In the experimental investigations made by the present writer in order to determine the conditions associated with zygospore production in more than a dozen different species, results have been obtained which may be summarized as follows:

Zygospore production in the Mucorineæ is conditioned by the inherent nature of the individual species and only secondarily or not at all by external factors.

According to their method of zygospore formation, the various species among the Mucorineæ may be divided into two main categories, which may be designated as *homothallic* and *heterothallic*, and which correspond respectively to monœcious and diœcious forms among the higher plants.

In the homothallic group, zygospores are developed from branches of the same thallus or mycelium and can be obtained from the sowing of a single spore. Although it has been currently assumed that all mucors belong to this class, it comprises but a very small percentage of the species and contains the only forms from which heretofore it has proved possible to obtain a constant production of zygospores. *Sporodinia grandis,* the only common species, is very frequent on decaying agarics, etc., and has served as a basis for experimentation in a majority of the investigations dealing with this subject.

In the heterothallic group, comprising a large majority of the species, zygospores are developed from branches which necessarily belong to thalli or mycelia diverse in character, and can never be obtained from the sowing of a single spore. Every heterothallic species is, therefore, an aggregate of two distinct strains through the interaction of which zygosporic reproduction is brought about. If inoculations of these two opposite strains of a given species are so disposed that their mycelia can grow together, there will be developed, at the region of contact, a distinct dark line produced by the accumulation of zygospores formed between filaments of the opposite strains. *Rhizopus nigricans,* the common bread mold which is used by nearly every elementary class in cryptogamic botany, may be taken as the type of this group. An accidental mixture of its two strains has been kept under cultivation for nearly ten years and as the 'Harvard strain' has furnished zygospores for class work to many botanical laboratories in this country.

In an individual species these sexual strains show in general a more or less marked differentiation in vegetative luxuriance, and the more and less luxuriant may be appropriately designated by the use of (+) and (—) signs respectively. In a few forms, no differentiation has been as yet detected; in others, one strain shows a less vegetative vigor when cultivated under unfavorable conditions; in the majority, however, the differentiation is evident from the marked difference in the gross appearance in cultures of the two opposite strains; and in one form, not only the habit of growth, but

the size of the spores are so diverse in the (+) and (—) strains that systematists generally would feel justified in describing them as separate species.

In heterothallic species, strains have been found which from their failure to react with (+) and (—) strains of the same form have been called 'neutral,' and a similar neutrality may be induced by cultivation under adverse conditions. A table under preparation to determine the relative abundance and distribution in nature of the (+), (—) and neutral strains of *Rhizopus* has so far shown that, although neutral strains are not uncommon, the majority of the cultures, obtained from various localities abroad and in this country, belong to either the (+) or the (—) strain.

In all species of both homo- and heterothallic groups in which the process of conjugation has been carefully followed, the swollen portions (*progametes*) from which the gametes are cut off do not grow toward each other, as currently believed, but arise as a result of the stimulus of contact between more or less differentiated hyphæ (*zygophores*) and are from the outset always normally adherent.

In some species the zygophores have been demonstrated to be mutually attractive (*zygotactic*).

In the *heterogamic* subdivision of the homothallic group, a distinct and constant differentiation exists between the zygophoric hyphæ and the gametes derived from them, but in the remaining homothallic forms and in all heterothallic forms no such differentiation is apparent. Thus, while in the heterothallic species the sexual difference inheres in the whole thallus of either strain, in the homothallic forms it is confined to the conjugating branches of a single thallus.

A process of imperfect hybridization will occur between *unlike* strains of different heterothallic species in the same or even in different genera, or between a homothallic form and *both* strains of a heterothallic species, and distinct white lines are produced in many cases at the regions of hybridization.

By taking advantage of this fact it has been possible to group together in two opposite series the strains of all the heterothallic forms under cultivation. When thus grouped, the (—) or less luxuriant strains will fall in one series, while the (+) or more luxuriant will be included in the other.

From the foregoing observations it may be concluded: (*a*) That the formation of zygospores is a sexual process; (*b*) that the mycelium of a homothallic species is bisexual; (*c*) while the mycelium of a heterothallic species is unisexual; (*d*) and further that in the (+) and (—) series of the heterothallic group are represented the two opposite sexes.

The writer intends during the coming year to continue his investigations on the subject of sexuality in the lower fungi, and would be greatly indebted to any mycologists who might be willing to assist him by sending culture material of any of the forms of the Mucorineæ which may be found producing zygospores.

Albert Francis Blakeslee.
Cryptogamic Laboratory,
Harvard University.

ON THE DEVELOPMENT OF PALISADE TISSUE AND RESINOUS DEPOSITS IN LEAVES.

In connection with the experimental investigation of the causes of xerophily in bog plants, new evidence as to the factors involved in the development of palisade cells and resinous deposits has been obtained. It has been found possible, in the case of *Rumex Acetosella* L., to greatly modify its external appearance and internal structure by growing it under various ecological conditions. When grown in moist conditions, with soil and air temperatures approximately the same, the leaves attain a relatively large size and their tissues are exceedingly loose. A poorly developed palisade of one cell-layer and three layers of spongy parenchyma, beneath it, make up the mesophyll. The epidermis is composed of large turgid thin-walled cells, having a very delicate cuticle on the outside.

When grown on dry sand the leaves are notably thickened, reduced in size and the margins become revolute. The mesophyll is very compact and consists of a palisade of two to three cell-layers and a spongy tissue of two cell-layers. The epidermal cells are small and

their outer walls are notably thickened. A well-developed cuticle is present.

It has been found that all of these xerophilous characters may be produced by growing the plant in an undrained wet sphagnum substratum, whose temperature is maintained several degrees below that of the air. This effect is obtained even in subdued light. Further, under these conditions the drops of oil or resin, so characteristic of bog xerophytes, are formed in the epidermis and the cells adjacent to the bundles. Such resinous deposits occur also in the plants grown on dry sand, but are wanting under favorable moisture conditions. It is believed that these modifications are, in the case of the bog habitat, a response to the unfavorable conditions for absorption by the roots, occasioned by the low substratum temperature and lack of proper aeration.

That palisade tissues may be greatly increased or developed in shaded conditions is also evident. The experiments suggest that even when such a response is obtained in strong light, it is to be correlated with drouth rather than with light. The increased transpiration brought about by direct insolation, as it increases the temperature and decreases the relative humidity of the air, would seem to be an efficient cause for palisade development. The elongated cells of the palisade, therefore, appear to be an adaptation for the ready transferrence of food materials in the leaf tissues, under the stress of a reduced water supply. The analogy of dry sand habitats and undrained wet bog habitats is certainly indicated.

The details of these experiments and others tending in the same direction will be published elsewhere.

EDGAR N. TRANSEAU.

UNIVERSITY OF MICHIGAN,
May 11, 1904.

ALBINO BROOK TROUT.

AMONG the brook trout hatched at the Adirondack Hatchery, Saranac Inn, N. Y., in March, 1902, there appeared to be some distinct albinos. There were about fifty of these fry out of an entire hatching of 800,000 ordinary brook trout eggs, taken from both wild and confined trout. These albinos were put by themselves, and four reached maturity.

Two of them are typical albinos. They are the same in outline as the ordinary brook trout. The skin is white, mottled with an ochraceous yellow, colored with the typical red and yellow spots. The fins are white, with the red band and yellow mottling. Eyes red. The general appearance of the fish is delicate, and the bones are apparently visible through the seemingly transparent skin. As these fish were reared in captivity they have been confined to the ordinary fish races, and fed on ground liver. One is a male, the other a female. The former now measures seven inches in length; the latter, nine inches.

The other two fish are a grayish white, with dark fins and black eyes.

On November 10, 1903, when the two albinos were twenty months old, they were stripped for eggs and fertilization. At this time their combined weight was approximately one half pound, the female being much the larger. Mr. G. E. Winchester, foreman of the Fish Hatchery, made the following experiments in fertilization: viz., first cross, 527 eggs from female albino $\times$ albino male; second cross, 103 eggs from female albino $\times$ natural male; third cross, 424 eggs from natural female $\times$ albino male.

The eggs, after fertilization, were placed in the hatchery races the same as all brook trout eggs. The hatching began March 1, 1904, and continued until the thirteenth of the month, the period of incubation being the same as that of the ordinary brook trout egg.

The result of the hatching was as follows: From the first cross 32 hatched, or approximately 6 per cent.; from the second cross 43 hatched, or approximately 42 per cent.; from the third cross 416 hatched, or approximately 98 per cent.

At the present time—one month after all the fish were hatched—the following number is living: from the first cross 20, or 62 per cent.; from the second cross none; from the third cross all, or 100 per cent.

The weakness of the pure albinos is indicated by the fact that only 6 per cent. of the eggs proved fertile, and several of these are

not perfect fish. Yet they have the characteristics of the albino parents.

Of the fry from the second cross 42 per cent. hatched; but none were alive at the end of one month. Some of them were imperfect in form, and were colored more like the natural male parent, but not entirely so.

From the third cross all the eggs were fertile except eight—a loss of but two per cent.—and all are living at the end of thirty days. There are practically no cripples, and the coloring is typical of the natural female parent.

The silver gray albinos did not spawn. They have the appearance of barren fish.

These fish were exhibited by this department at the New York state fair last fall and attracted much attention.

C. R. Pettis.

Forest, Fish and Game Commission,
Albany, N. Y.,
April 15, 1904.

BOTANICAL NOTES.

WEEDS USED IN MEDICINE.

Under this title the United States Department of Agriculture issues an interesting bulletin (Farmers' Bulletin, No. 188) prepared by Alice Henkel, assistant in drug and medicinal plant investigations. The author calls attention to the fact that many of the common weeds of the farm and garden possess medical properties, and in some cases might be collected and made a source of revenue. Thus in his fight with the plant pests in his fields the farmer may actually turn them to some account, by collecting and preparing them for the market as crude drugs. Directions are given for collecting and curing, and suggestions are made as to their disposal when ready for the market. They are first considered under roots, barks, leaves and herbs, flowers and seeds. Following this are descriptions of some of the more common weeds which have medicinal importance, illustrated by a number of good figures. No less than twenty-four species are taken up in this part of the bulletin. It should prove very useful to many farmers and gardeners.

THE DATE PALM IN AMERICA.

In a recent bulletin (No. 53) of the Bureau of Plant Industry of the United States Department of Agriculture, Walter T. Swingle makes a report of his investigations of the date palm as grown in Algeria, and of the attempts to introduce it into California and Arizona. The purpose of the bulletin, as stated by the author, "is to call attention to the peculiar suitability of the date palm for cultivation in the hottest and most arid regions in the southwestern states, and to its remarkable ability to withstand large amounts of alkali in the soil. The most intense heat, the most excessive dryness of the air, the absence of all rainfall for months at a time during the growing season, and even the hot, dry winds that blow in desert regions, are not drawbacks, as in almost all other cultures, but positive advantages to the date palm, enabling it to mature fruit of the highest excellence." The author shows that the Salton Basin in California 'is not only the most promising region in the United States, or in North America, for the culture of the best sort of dates, but that it is actually better adapted for this profitable culture than those parts of the Sahara Desert where the best exported dates are produced.' It is shown to be probable that this single region is capable of producing dates enough to supply the demand for the whole country. Other regions in California, Nevada, Arizona, New Mexico and Texas are discussed, the conclusion being that in all of these states date palms of certain varieties may be grown with profit.

From the bulletin it appears that there are three principal types of dates cultivated by the Arabs, viz: 'soft dates,' which are very sugary and include the sorts with which we are familiar; 'sour dates,' which contain a much lower percentage of sugar, not enough, in fact, to preserve them; 'dry dates,' which are not at all soft or sticky when ripe, and which may be stored and kept indefinitely. None of the last are to be found in the American markets, and scarcely any of the second type. Of the 'soft dates,' the variety which bears the name of 'Deglet Noor' is the most famous. It is very late in maturing,

but yields a fruit of great excellence. We are assured that this variety can be grown in the Salton Basin, California.

WOODY PLANTS IN WINTER.

K. M. WIEGAND and F. W. Foxworthy, of Cornell University, have published a handy pamphlet which should be very useful to foresters, horticulturists, schoolteachers and others who do not have such an intimate personal acquaintance with trees and shrubs as will enable them to recognize them in their winter condition. By means of carefully made keys the genus of any woody plant, native or planted in the state of New York, may be determined with a good deal of certainty. The authors hope to bring out later a similar set of keys to the species.

DOCTOR AUGUSTIN GATTINGER, BOTANIST.

BORN in Munich, Germany, in 1825, educated in the Gymnasium and University of Munich, emigrated to Tennessee when twenty-four years of age, practised medicine and studied the flora of Tennessee for many years, published 'Trees and Shrubbery Adapted to the Soil and Climate of Nashville' (1878), 'Tennessee Marbles' (1883), 'Botanical Fragments' (1884), 'The Tennessee Flora' (1887), 'The Medicinal Plants of Tennessee' (1894), 'The Flora of Tennessee' (1901), died in his home in Nashville, July 18, 1903. Such is the brief summary of the life of a pleasant, genial, industrious man who loved plants, and studied them because he loved them.

In the *American Historical Magazine* for April, 1904, there appeared a sympathetic biographical sketch (28 pp.) of the life of Dr. Gattinger, by Robert A. Halley, accompanied with a fine portrait. This has been printed separately for distribution among botanical and other friends. CHARLES E. BESSEY.

SCIENTIFIC NOTES AND NEWS.

THE University of Toronto conferred, on May 27, the honorary degree of LL.D. upon President Harper, of the University of Chicago; Professor Minot, of Harvard University; Professor Saunders, of the Dominion Experimental Farm, Ottawa; Mr. W. S. King, Dominion astronomer, and his assistant, Mr. Otto Klotz; and Captain Deville, surveyor-general, Ottawa.

CAMBRIDGE UNIVERSITY conferred, on May 28, the following doctorates of science: Hendricus Gerardus van de Sande Bakhuysen, president of the Royal Academy of Sciences, Amsterdam, professor of astronomy in the University of Leiden; Andrej Sergejevich Famintsyn, member of the Imperial Academy of Sciences of St. Petersburg; Edmund Mojsisovics, Edler von Mojsvár, member of the Imperial Academy of Sciences, Vienna; Gustav Retzius, member of the Royal Swedish Academy of Sciences, emeritus professor of anatomy in the University of Stockholm; Eduard Riecke, member of the Royal Academy of Sciences, Göttingen, professor of physics in the University of Göttingen; Wilhelm Waldeyer, secretary of the Royal Prussian Academy of Sciences, Berlin, professor of anatomy in the University of Berlin.

THE senate of the Royal University of Ireland has resolved to confer, *honoris causa,* the degree of doctor of science on Sir William Crookes, F.R.S., and on Professor James Dewar, F.R.S.

A COMPLIMENTARY dinner was given on May 16 in London to Major-General E. R. Festing, C.B., F.R.S., upon his retirement from the post of director of the science division of the Victoria and Albert Museum.

PROFESSOR R. S. WOODWARD, dean of the faculty of pure science, will be the delegate from Columbia University at the celebration of the fiftieth anniversary of the founding of the University of Wisconsin, on June 5 to 9.

DR. L. O. HOWARD, chief entomologist of the Department of Agriculture and permanent secretary of the American Association, has returned to Washington after investigations in the southern states and Mexico.

PROFESSOR R. W. WOOD, professor of experimental physics at the Johns Hopkins University, has gone to Europe, where he will carry on investigations during the summer.

Dr. J. B. Johnston, professor of zoology at West Virginia University, has been granted leave of absence for the year 1904–05. He will spend July and August at the Bermuda Biological Station, from September 1 to March 1 at the Naples Zoological Station, and the remainder of the time in Germany. At Naples he will occupy the Smithsonian table.

President Andrew D. White is expected to return to America in time for the commencement exercises of Cornell University.

Mr. Austin H. Clark, of Boston, who is now on a collecting trip among the less-known islands of the British West Indies, has been elected a fellow of the Royal Geographical Society of London.

The Carnegie Institution has made a grant to Mr. A. F. Blakesley, of Harvard University, to enable him to spend next year abroad continuing his investigations in mycology. He will leave after the close of the Harvard Summer School.

It is announced that Mr. Marconi will return to Cape Breton early in June to conduct the trans-Atlantic wireless service.

The following provisional program of evening lectures at the Marine Biological Laboratory, Woods Hole, Mass., has been arranged. Other lectures will be announced later.

July 2. Mr. Lynds Jones. 'The Migrations of Birds.'

July 5. Professor Jacob Reighard. 'The Breeding Habits and Secondary Sexual Characters of some Brook Fishes.'

July 7. Professor A. D. Mead. 'The Houseboat as a Biological Laboratory.'

July 11. Professor E. P. Lyon. 'Physiological Rhythms in Cleavage.'

July 15. Professor A. P. Mathews. 'The Physical Basis of some Vital Phenomena.'

July 20. Professor C. O. Whitman. 'The Evolution of Color Pattern.'

July 29. Dr. R. M. Yerkes. 'Automatism and Intelligence in Frogs.'

August 1. Dr. R. M. Strong. 'The Colors of Birds.'

August 3. Dr. Theo. N. Gill. 'The History of the Ichthyology of Massachusetts.'

Dr. G. S. Huntington, professor of anatomy in the College of Physicians and Surgeons, Columbia University, will give the Shattuck lecture before the Massachusetts Medical Society, on June 7.

According to the program, lectures were to be given before the Royal Institution as follows: On May 24 Mr. H. F. Newall began a course of two lectures on the Solar Corona; on May 26, Mr. N. G. Wells delivered the first of two lectures on Literature and the State; on May 28, Sir Martin Conway began a course of two lectures on Spitzbergen in the seventeenth century. The Friday evening discourse on May 27 was delivered by the Prince of Monaco on the Progress of Oceanography; and on June 3 Professor Svante Arrhenius lectured on the Development of the Theory of Electrolytic Dissociation.

Dr. George Oliver, a fellow of the Royal College of Physicians, London, has presented to the college the sum of $10,000 in trust for the endowment of a lectureship or prize to be called the Oliver-Sharpey Lectureship or Prize, in memory of the late William Sharpey, F.R.S., professor of physiology in University College, London.

Professor William Henry Pettee, professor of mineralogy, economic geology and mining at the University of Michigan since 1875, died suddenly at Ann Arbor on May 26. He was born in 1838, graduated from Harvard in 1861 and studied subsequently for three years in the Royal Saxon Academy of Mines. He was assistant in chemistry and instructor in mineralogy at Harvard University for four years and went to the University of Michigan in 1871 as assistant professor. He was a fellow and, in 1887, general secretary of the American Association; a member and, in 1880, vice-president of the American Institute of Electrical Engineers, and a member of the Geological and Philosophical Societies.

The death is announced of Wilhelm von Siemens, a member of the eminent family which has contributed so much to the advancement of electrical science and himself an able inventor.

There will be a civil service examination, on June 22, to fill a vacancy in the position

of assistant chemist, at $1,400 per annum, in the Bureau of Standards.

THE sixth International Congress of Physiology will be held at Brussels, in the Institut Solvay, from August 30 to September 3, 1904, under the presidency of Professor Heger. One meeting will be devoted to the report of the International Commission appointed at Cambridge in 1898 for the unification of standards in physiology (Association de l'Institut Marey) and to the nomination of a committee of arrangements for the following congress. If the number of communications warrants, special sections, for example, in physiological chemistry or in experimental psychology, may be organized, as at Turin. Further information may be obtained from Dr. Auguste Slosse, local secretary, Institut Solvay, Parc Léopold, Brussels, Belgium.

THE Royal Geographical Society held its annual meeting on May 15; the medals and other honors were presented to those whose names have already been announced. The annual address of the president, Sir Clements Markham, was largely concerned with the British Antarctic Expedition, but geographical progress in other parts of the world was also described. It was stated that efforts are being made to secure $600,000 for the erection of a new building for the society. The annual dinner of the society was held on the evening of the same day, when speeches were made by the president, Sir Harry Johnston, Sir William Ramsay and others.

THE Chicago Academy of Sciences has secured the collection of lower coal measure plants made by Dr. John H. Britts, of Clinton, Iowa. The collection contains many species named by Lesquereux besides numerous cotypes of species described by David White in Monograph 37, U. S. Geological Survey, on the 'Fossil Flora of the Lower Coal Measures of Missouri.' The collection was obtained through the generosity of Mr. Francis S. Peabody of Chicago.

A CORRESPONDENT writes to the London *Times* from Alexander on May 6: "Dr. Koch has concluded his investigations into the question of the cattle plague. His report, which was laid before the ministry yesterday, is disappointing to those who anticipated prompt and effectual measures for the eradication of the disease. The learned bacteriologist considers the plague an extremely mild form of rinderpest, and one more nearly allied to Texas and Transcaucasian fever, the germ conveying the infection bearing also some analogy to the parasite found in coast fever in West Africa. His suggestions are confined to advising the government to pursue the measures already adopted, such as the application of injections and the isolation of infected animals. Dr. Koch sailed on May 6 for Marseilles."

WE learn from *Electrical World* that a deputation of Canadian electrical interests has waited upon the minister of inland revenue asking that the government establish an electrical standardizing bureau, to be maintained independent of any other branch of the public service, and placed in charge of a qualified electrical expert, at whose disposal should be placed trained assistants and proper facilities. The delegation also asked that the law be amended so that if any device was found in the possession of any one to prevent the proper registration of electric current, it should be *prima facie* evidence for his prosecution and conviction.

UNIVERSITY AND EDUCATIONAL NEWS.

MR. JOHN D. ROCKEFELLER has given the Case School of Applied Science $200,000 to be used for building and equipping laboratories for physics and mining engineering. The buildings will be erected during the coming year.

YALE UNIVERSITY will receive as residuary legatee over $250,000 from the estate of William B. Ross, a lawyer of New York City, who died on January 14 last. A portion of this sum will be used for the erection of an addition to the library building.

THE will of the late Professor Maxwell Sommerville provides $20,000 for the preservation and care of the collection of engraved gems and ethnological collections given by him to the University of Pennsylvania some years ago.

THE forestry department of the University of Michigan has received a gift of about ninety species, including over five hundred specimens of forest trees, from Robert Douglas's Sons, forest tree nurserymen, of Waukegan, Ill. The material was selected at the invitation of the donors, by Professor Roth and Mr. Davis, of the forestry department, and will at once be set out on the Saginaw Forest Farm.

THE new range of greenhouses of the New Hampshire College of Agriculture was opened on May 20. There were over two hundred visitors in attendance, to whom a reception was given by Professor F. W. Rane, head of the department of horticulture. The greenhouses have been erected at a cost of $7,000, appropriated by the state, and offer many facilities for instruction and research.

A plan for the reorganization of the faculty of the department of medicine of the University of Pennsylvania has been approved by the trustees, whereby the faculty membership has been extended to the clinical, associate and assistant professors, to the associates and lecturers and to a limited representation from the subordinate staff. The scheme provides for an executive body or council, to be composed of the heads of departments in fundamental subjects and two representatives of the specialties. Jefferson Medical College has adopted a similar plan, electing all the clinical professors to a full professorship.

Two pieces of foreign educational news may be noted: The resident members of the Oxford convocation voted by a large majority to permit those not in priests' orders to be examiners in the school of theology, but convocation, composed largely of absent clergymen, rejected this measure by a vote of 676 to 278. This is perhaps only natural conservatism, but the Prussian Chamber of Deputies on the same day, May 17, adopted a resolution which is reactionary, namely, that the elementary national schools shall, as a rule, be either Protestant or Roman Catholic, that each school shall contain, as a rule, pupils belonging to one faith only and that these pupils shall be instructed by teachers who profess their own creed. A somewhat similar bill was proposed by the minister of education in 1891, but owing largely to opposition in academic circles was defeated, whereupon the minister and the president of the ministry, Count von Caprivi, resigned.

THERE is a vacant instructorship in Chemistry in Denison University, Granville, Ohio. Instructor W. B. Clark has been granted leave of absence to pursue graduate work in the University of Chicago.

WE are asked to state that a position as assistant in physiology is open for applicants in the University of Pennsylvania.

IT is announced that Professor George Trumbull Ladd has resigned his chair of philosophy at Yale University.

PROFESSOR CHARLES BASKERVILLE, of the University of North Carolina, has been elected professor of chemistry in the College of the City of New York.

AT Cornell University, Dexter S. Kimball has been appointed Sibley professor of mechanic arts, in charge of the Sibley shops. Professor Kimball succeeds Professor John L. Morris, who, after continuous service since 1868, will become professor emeritus in June. Instructors have been appointed as follows: C. N. Haskins in mathematics, H. H. Cochran, W. J. Fisher and G. L. Manning in physics, W. C. Geer in chemistry, G. D. Hubbard in geology and E. A. Gray and P. Anderson in anatomy.

DR. R. BURTON-OPITZ has been appointed adjunct professor of physiology in Columbia University and has been assigned a seat in the faculty of pure science.

AT the University of Nebraska, Mr. G. E. Condra has been promoted to a professorship of geology and Mr. H. S. Evans to an adjunct professorship of electrical engineering.

APPOINTMENTS have been made at McGill University, as follows: Dr. R. Tait Mackenzie, to be lecturer in anatomy; Dr. A. A. Robertson, to be lecturer in physiology; J. R. Roebuck, to be lecturer in chemistry; Dr. W. S. Morrow, to be associate professor of physiology; Dr. A. G. Nicholls, to be associate professor of pathology and bacteriology; A. S. Eve, to be lecturer in mathematics, and Dr. Coker, to be associate professor of engineering.